533 Rec'd PCT/PTO 04 SEP 2001

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U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY'S DOCKET NUMBER 1454.1095
INTERNATIONAL APPLICATION NO. PCT/DE99/00562	INTERNATIONAL FILING DATE March 3, 1999	PRIORITY DATE CLAIMED 09/914842

TITLE OF INVENTION
FREQUENCY DIVISION MULTIPLEX TRANSCEIVER AND METHOD FOR ELIMINATING CROSSTALK

APPLICANT(S) FOR DO/EO/US
Thomas OSTERTAG et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [X] This is an express request to immediately begin national examination procedures (35 U.S.C. 371(f)).
3. [X] The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
4. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
5. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
6. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
7. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
8. [ ] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)).
9. [ ] A translation of the Annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 10-15 below concern document(s) or information included:

10. [ ] An Information Disclosure Statement Under 37 CFR 1.97 and 1.98.
11. [ ] An assignment document for recording.
    Please mail the recorded assignment document to:
    a. [ ] the person whose signature, name & address appears at the bottom of this document.
    b. [ ] the following:
12. [X] A preliminary amendment.
13. [X] A substitute specification
14. [ ] A change of power of attorney and/or address letter.
15. [X] Other items or information:
    Amended specification submitted in International Application (with Translation), International Search Report, Translated abstract from published International Application.
    IDS with references will follow.

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09/914842

[X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees as follows:

CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS	15 -20=	0	x $ 18.00	0.00
	INDEPENDENT CLAIMS	2 -3=	0	x $ 80.00	0.00
	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+$270.00	0.00
	BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(4): [ ] Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ....$1,000 [X] International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.. ....$ 860 [ ] International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO...................$ 710 [ ] International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provision of PCT Article 33(1)-(4)..............$ 690 [ ] International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4) ....$ 100				860.00
	Surcharge of $130 for furnishing the National fee or oath or declaration later than [ ] 20 [X] 30 mos. from the earliest claimed priority date (37 CFR 1.482(e)).				130.00
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	Fee for recording the enclosed assignment (37 CFR 1.21(h)).				+
			TOTAL FEES ENCLOSED		990.00

a. [X] A check in the amount of $990.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. 19-3935 in the Amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.

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21171

PATENT TRADEMARK OFFICE

Sept. 4, 2001

DATE

NAME Mark J. Henry

REGISTRATION NO. 36,162

09/914842
JC03 Rec'd PCT/PTO 04 SEP 2001

Docket No.: 1454.1095

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

Thomas OSTERTAG et al.

Serial No. NEW | Group Art Unit: To be assigned

Confirmation No.

Filed: September 4, 2001 | Examiner: To be assigned

For: FREQUENCY DIVISION MULTIPLEX TRANSMITTER AND METHOD FOR ELIMINATING CROSSTALK

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Before examination of the above-identified application, please amend the application as follows:

IN THE ABSTRACT:

Please REPLACE the Abstract originally filed with the enclosed Substitute Abstract attached hereto.

IN THE SPECIFICATION:

Please REPLACE the specification originally filed with the enclosed Substitute Specification.

IN THE CLAIMS:

Please REPLACE claims 1-15 in accordance with the following:

1. (ONCE AMENDED) A frequency division multiplex transceiver having the following

features: a baseband block, a transmit path with a local oscillator and a first receive path are connected to one another in such a way that they respectively transmit and receive simultaneously on different frequencies, an auxiliary transmit path having a mixer supplied by the local oscillator is connected to the first receive path and adds to the received signal a signal whose phase is shifted by 180° with respect to the phase of the crosstalk portion in the first receive path at the summation or superposition point and which has the same frequency or the same frequency range as the transmit signal,

the auxiliary transmit path can be driven by the baseband block independently of the first transmit path in such a way that the compensation signal is present at the output of the mixer .

2. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 1, wherein the baseband block senses crosstalk of the transmit path and drives the auxiliary transmit path as a function of the sensing of the crosstalk.

3. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2, wherein the baseband block senses the amplitude and phase of the crosstalk of the transmit path as a function of the transmit frequency.

4. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2, wherein, in order to sense the crosstalk of the transmit path, the receive signal and the crosstalk can be fed unfiltered to the baseband block .

5. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2, wherein, in order to sense the crosstalk of the transmit path, a second receive path is provided which has a further mixer which downmixes the crosstalk on the basis of the transmit frequency currently used.

6. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 1, wherein the baseband block drives the auxiliary transmit path to minimize the sensed crosstalk of the transmit path .

7. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim

1, wherein the baseband block drives the auxiliary transmit path in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

8. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 1, wherein, in order to drive the auxiliary transmit path, the baseband block carries out a folding calculation of the crosstalk with the transmit signal in the time domain.

9. (ONCE AMENDED) A method for eliminating crosstalk in a frequency division multiplex transceiver having the following features:

a baseband block, a transmit path and a first receive path transmit and receive simultaneously on different frequencies,

an auxiliary transmit path which is connected to the first receive path, adds to the received signal a signal whose phase is shifted by 180° with respect to the phase of the crosstalk portion in the first receive path at the summation or superposition point, the signal having the same frequency or the same frequency range as the transmit signal,

the baseband block drives the auxiliary transmit path to minimize the crosstalk, independently of the transmit path .

10. (ONCE AMENDED) The method as claimed in claim 9, wherein the baseband block senses crosstalk of the transmit path and drives the auxiliary transmit path as a function of the sensing of the crosstalk.

11. (ONCE AMENDED) The method as claimed in claim 10, wherein the baseband block senses the amplitude and phase of the crosstalk of the transmit path as a function of the transmit frequency.

12. (ONCE AMENDED) The method as claimed in claim 10, wherein, in order to sense the crosstalk of the transmit path, the receive signal and the crosstalk are fed unfiltered to the baseband block .

13. (ONCE AMENDED) The method as claimed in claim 10, wherein, in order to sense the crosstalk of the transmit path, a second receive path is used in which the crosstalk is downmixed on the basis of the transmit frequency currently used.

14. (ONCE AMENDED) The method as claimed in claim 9, wherein the baseband block drives the auxiliary transmit path in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

15. (ONCE AMENDED) The method as claimed in claim 9, wherein, in order to drive the auxiliary transmit path, the baseband block carries out a folding calculation of the crosstalk with the transmit signal in the time domain.

REMARKS

This Preliminary Amendment is submitted to improve the form of the specification as originally-filed. A substitute specification and marked-up copy of the original specification are enclosed. No new matter is added to these documents.

It is respectfully requested that this Preliminary Amendment be entered in the above-referenced application.

If any further fees are required in connection with the filing of this Preliminary Amendment, please charge same to our Deposit Account No. 19-3935.

Respectfully submitted,

STAAS & HALSEY LLP

Date: September 4, 2001

By: Mark J. Henry

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Please AMEND the paragraph beginning at page *, line *, as follows:

Please DELETE the entire contents of line * at page *.

IN THE CLAIMS:

Please AMEND the following claims:

1. (ONCE AMENDED) A frequency division multiplex transceiver having the following features: a baseband block [(18)], a transmit path [(S1)] with a local oscillator [(6)] and a first receive path [(E1)] are connected to one another in such a way that they respectively transmit and receive simultaneously on different frequencies, an auxiliary transmit path [(S2)] having a mixer [(11)] supplied by the local oscillator [(6)] is connected to the first receive path [(E1)] and adds to the received signal [(E1)] a signal whose phase is shifted by 180° with respect to the phase of the crosstalk portion in the first receive path [(E1)] at the summation or superposition point and which has the same frequency or the same frequency range as the transmit signal,

the auxiliary transmit path [(S2)] can be driven by the baseband block [(18)] independently of the first transmit path [(S1)] in such a way that the compensation signal is present at the output of the mixer [(11)].

2. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 1, [characterized in that]wherein the baseband block [(18)] senses crosstalk of the transmit path [(S1)] and drives the auxiliary transmit path [(S2)] as a function of the sensing of the crosstalk.

3. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2, [characterized in that]wherein the baseband block [(18)] senses the amplitude and phase of the crosstalk of the transmit path [(S1)] as a function of the transmit frequency.

4. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2 [or 3], [characterized in that]wherein, in order to sense the crosstalk of the transmit path [(S1)], the receive signal and the crosstalk can be fed unfiltered to the baseband block [(18)].

5. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in claim 2 [or 3], [characterized in that]wherein, in order to sense the crosstalk of the transmit path [(S1)], a second receive path [(E2)] is provided which has a further mixer [(12)] which downmixes the crosstalk on the basis of the transmit frequency currently used.

6. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in [one of the preceding claims]claim 1, [characterized in that]wherein the baseband block [(18)] drives the auxiliary transmit path [(S2)] to minimize the sensed crosstalk of the transmit path [(S1)].

7. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in [one of the preceding claims]claim 1, [characterized in that]wherein the baseband block [(18)] drives the auxiliary transmit path [(S2)] in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

8. (ONCE AMENDED) The frequency division multiplex transceiver as claimed in [one of the preceding claims]claim 1, [characterized in that]wherein, in order to drive the auxiliary transmit path [(S2)], the baseband block [(18)] carries out a folding calculation of the crosstalk with the transmit signal in the time domain.

9. (ONCE AMENDED) A method for eliminating crosstalk in a frequency division multiplex transceiver having the following features:

a baseband block [(18)], a transmit path [(S1)] and a first receive path [(E1)] transmit and receive simultaneously on different frequencies,

an auxiliary transmit path [(S2)] which is connected to the first receive path [(E1)], adds to the received signal [(E1)] a signal whose phase is shifted by 180° with respect to the phase of the crosstalk portion in the first receive path [(E1)] at the summation or superposition point, the signal having the same frequency or the same frequency range as the transmit signal,

the baseband block [(18)] drives the auxiliary transmit path [(S2)] to minimize the crosstalk, independently of the transmit path [(S1)].

10. (ONCE AMENDED) The method as claimed in claim 9, [characterized in

that]wherein the baseband block [(18)] senses crosstalk of the transmit path [(S1)] and drives the auxiliary transmit path [(S2)] as a function of the sensing of the crosstalk.

11. (ONCE AMENDED) The method as claimed in claim 10, [characterized in that]wherein the baseband block [(18)] senses the amplitude and phase of the crosstalk of the transmit path [(S1)] as a function of the transmit frequency.

12. (ONCE AMENDED) The method as claimed in claim 10 [or 11], [characterized in that]wherein, in order to sense the crosstalk of the transmit path [(S1)], the receive signal and the crosstalk are fed unfiltered to the baseband block [(18)].

13. (ONCE AMENDED) The method as claimed in claim 10 [or 11], [characterized in that]wherein, in order to sense the crosstalk of the transmit path [(S1)], a second receive path [(S2)] is used in which the crosstalk is downmixed [(12)] on the basis of the transmit frequency currently used.

14. (ONCE AMENDED) The method as claimed in [one of claims 9 to 13, characterized in that]claim 9, wherein the baseband block [(18)] drives the auxiliary transmit path [(S2)] in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

15. (ONCE AMENDED) The method as claimed in [one of claims 9 to 14, characterized in that]claim 9, wherein, in order to drive the auxiliary transmit path [(S2)], the baseband block [(18)] carries out a folding calculation of the crosstalk with the transmit signal in the time domain.

Abstract

Crosstalk is eliminated in a transceiver which is operated in a frequency-division-multiplex full duplex mode. The technique is suitable in particular for what is referred to as software-defined telecommunications equipment. The frequency division multiplex transceiver has a baseband block, a transmit path and a receive path which respectively transmit and receive on different frequencies (full duplex mode). Furthermore, an auxiliary transmit path is provided which is connected to the receive path and which adds to the received signal a signal whose phase is shifted by 180° with respect to the phase of the crosstalk portion in the first receive path at the summation or superimposition point and which has the same frequency range as the transmit signal. The auxiliary transmit path is driven here, independently of the first transmit path, by the baseband block so as to minimize the crosstalk sensed by the baseband block.

Description

Frequency division multiplex transmitter and method for eliminating crosstalk

The present invention relates to a frequency division multiplex transmitter and to a method for eliminating crosstalk in a frequency division multiplex transmitter as claimed in the preamble of claims 1 and 9.

When mobile radio devices are constructed, it is necessary to take measures to protect the RF stage against overloading by strong interference signals or other undesired signals. A potential source of interference signals is crosstalk which is generated by the transmit path of a transmitter when it is operated in what is referred to as the full-duplex-frequency division multiplex mode. If the crosstalk generated by the transmit path is very strong in this operating mode, the receive path of the transmitter cannot operate satisfactorily, in particular at relatively weak received signal levels.

On the other hand, in what is referred to as a software-defined mobile radio device or a similar telecommunications device, the RF stage covers a very wide frequency spectrum (for example in a range from several hundred megahertz as far as the gigahertz range). The reason for this is it is intended that in the future a mobile radio device should, if appropriate, also be capable of covering a plurality of standards (GSM, DECT, UMTS, etc.).

Furthermore, a software-defined mobile radio device permits the duplex spacing to be set in a variable and flexible way. For this reason, in this case crosstalk from the transmit path is a particularly critical point which needs to be dealt with.

Theoretically, as far as such elimination of the crosstalk generated by the transmit path is concerned, filter-like duplexers, bandpass filters or stopband filters can be used to reduce the crosstalk in the receive path. These concepts can, of course, also be used in software-defined telecommunications radio devices. However, in the aforesaid technologies the frequency band and the duplex spacing are permanently predefined. On the other hand, this is generally not the case in software-defined devices. This means that, for example, the filters or the duplexers, must be embodied so as to be tunable so that they can also be used with variable frequency bands or duplex spacings. Such tunable filters, duplexers or the like are, however, difficult to implement and are not available at present owing to the requirements made of the size, the weight, the energy consumption and the linearity of mobile radio devices or similar products.

In summary, there are therefore two basic problems which make it more difficult to eliminate the crosstalk:

a) large transmit/receive frequency range which has to be covered in particular by mobile radio devices which operate according to a plurality of standards (DECT, UMTS, GSM), and

b) the frequency dependence (frequency response) of the crosstalk within the transmission bandwidth itself.

A further known technology for reducing stray field influences is the analog elimination of crosstalk in the RF stage. According to this technology, part of the transmit power of the transmit path is branched off as an elimination signal and coupled into the receive path with a phase shift of 180° with respect to the transmit signal and with the same frequency as the transmit signal. To do this, a damping element and a phase shifter are provided. The necessary phase shift of 180° is however virtually impossible to obtain in the case

of a frequency dependence (frequency response) of the crosstalk within the transmission bandwidth itself because the damping

element and the phase shifter generally have a smooth transmission curve.

The object of the present invention has therefore been defined as making available a technique for eliminating crosstalk in frequency division multiplex transmitters which also provides satisfactory results for the case of a frequency dependence (frequency response) of the crosstalk within the transmission bandwidth itself and/or in mobile radio devices which cover a plurality of standards.

The object is achieved according to the present invention by means of the features of the independent claims. The dependent claims develop the central idea of the invention in a particularly advantageous fashion.

The invention therefore provides a frequency division multiplex transmitter which has a baseband block, a first transmit path and a receive path. The transmit path and the receive path respectively transmit and receive simultaneously on different frequencies (full duplex technology). Furthermore, what is referred to as an auxiliary transmit path is provided which is connected to the receive path and which adds to the received signal a signal whose phase is shifted by 180° with respect to the phase of the transmit signal and which has the same frequency or the same frequency range as the transmit signal. The method therefore comprises what is referred to as an active elimination of crosstalk. According to the present invention, the auxiliary transmit path can be driven by the baseband block independently of the first transmit path.

The baseband block can sense crosstalk of the first transmit path and then drive the auxiliary transmit path as a function of the sensing of the crosstalk.

The baseband block can in particular sense the amplitude and the phase of the crosstalk of the first transmit path as a function of the transmit frequency.

In order to sense the crosstalk of the first transmit path, it is possible to provide for the receive signal and the crosstalk to be fed unfiltered to the baseband block.

In order to sense the crosstalk of the first transmit path, it is possible to provide a second receive path which is independent of the first receive path and has an intermediate frequency converter which downmixes the crosstalk on the basis of the transmit frequency just used.

The baseband block can drive the auxiliary transmit path to minimize the sensed crosstalk of the first transmit path.

The baseband block can drive the auxiliary transmit path in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

In the time domain, the baseband block can carry out a convolution calculation of the crosstalk with the transmit signal in order to drive the auxiliary transmit path.

The present invention also provides a method for eliminating the crosstalk in a frequency division multiplex transmitter. The frequency division multiplex transmitter has a baseband block, a first transmit path and a receive path which respectively transmit and receive simultaneously on different frequencies. Furthermore, an auxiliary transmit path is provided which is connected to the receive path and which adds to the received signal a signal whose phase is *shifted*

by 180° with respect to the phase of the transmit signal and has the same frequency or the same frequency range as the transmit signal, so that an active

elimination of the crosstalk takes place. The baseband block drives the auxiliary transmit path to minimize the crosstalk, independently of the first transmit path.

The baseband block can sense crosstalk of the first transmit path and then drive the auxiliary transmit path as a function of the sensing of the crosstalk.

The baseband block can sense the amplitude and phase of the crosstalk of the first transmit path as a function of the transmit frequency.

In order to sense the crosstalk of the first transmit path, the receive signal and the superimposed crosstalk can be fed unfiltered to the baseband block.

In order to sense the crosstalk of the first transmit path, a second receive path can be used in which the crosstalk is downmixed on the basis of the transmit frequency, just used, of the first transmit path.

The baseband block can drive the auxiliary transmit path in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

In order to drive the auxiliary transmit path, the baseband block can carry out a convolution calculation of the crosstalk with the transmit signal in the time domain.

In what follows, a preferred exemplary embodiment of the invention will now be explained in more detail so that further features, properties and advantages of the present invention become clear.

Here, reference is made to the appended figure which is a schematic view of a block circuit diagram of an

exemplary embodiment of a frequency division multiplex transmitter according to the invention.

The figure shows that a total of four transmit and receive paths are provided between a power amplifier 3, or a receiving amplifier with low noise 4, and a baseband block 18, said transmit and receive paths being namely:

- the actual first transmit path S1 which is used to emit signals,
- the actual first receive path E1 which is used to receive signals,
- what is referred to as an auxiliary transmit path S2 which does not have any actual transmitting function but instead serves only to actively eliminate the crosstalk of the first transmit path S1, and
- a second receive path E2 which, in contrast to the first receive path E1 does not have any actual reception function but rather is merely used to sense the crosstalk which is generated by the first transmit path S1 in the full duplex mode.

In what follows, the individual paths of the frequency division multiplex transmitter according to the invention illustrated in the figure, which is operated in full duplex mode, will now be explained in detail.

First, the first transmit path S1 will be explained. Data to be transmitted is sent from the baseband block 18, for example, on a first intermediate frequency TX1, to a digital/analog converter 8. This digital/analog converter 8 then transmits the I and Q component of the data to a converter 7, which is connected to a local oscillator 6 at the frequency TXLO, and thus converts the data which is to be output to the transmit frequency range. The output signal of the converter 7 is transmitted to a power amplifier 3 which is connected to an antenna 1 by means of a duplexer 2. In the event of two different antennas being used for the transmit and receive modes there is, of course, no need for a duplexer 2.

Now, the first receive path E1 will be explained. In the full duplex mode, signals are received by the antenna 1 at the same time as the transmit mode in the first transmit path S1, and are transmitted by means of the duplexer 2 to a receiving amplifier 4 with low noise (LNA - Low Noise Amplifier). The output signal of the receiving amplifier 4 is transmitted to a demultiplexer 10 which is connected to a local oscillator 9 at the receive frequency RXLO. In this way, the received signals are downmixed to an intermediate frequency RX1, the I and Q components of the received signals are sensed and transmitted by means of a first filter 13 to an AD converter 16 which then feeds the data digitized in this way to the baseband block..

The second (auxiliary) transmit path S2 will now be explained. This second auxiliary transmit path S2 is driven independently of the first transmit path S1 of the baseband block 18, i.e. the corresponding baseband signals are transmitted to a DA converter 14 which then feeds the corresponding I'/Q' components at the intermediate frequency TX2 to a multiplexer 11. The multiplexer 11 converts the fed data, i.e. the I'/Q' components to the transmit frequency TXLO which corresponds to that frequency or that frequency band which is currently being used in the first transmit path S1. The baseband block 18 drives in such a way that the phase of the signal in the auxiliary transmit path S2 is precisely 180° with respect to the crosstalk portion in the first receive path E1.

The output signal of the multiplexer 11 of the second transmit path S2 is in turn power-amplified by the amplifier 5 and then fed to a coupler 19 in order to couple it into the first receive path E1 in such an amplified form. The second auxiliary transmit path S2 is driven by the baseband block 18 here in such a way that crosstalk which is generated by the first

transmit path S1 in the full duplex mode is eliminated or at least subsequently reduced,

as a result of the coupling of the output signal of the auxiliary transmit path S2 into the first receive path E1 by the coupler 19.

The second receive path E2 which, as explained in more detail below, is merely an option and does not necessarily have to be provided, will now be explained. In the second receive path E2, the output signal of the receiving amplifier 4 of the first receive path E1 is fed to the multiplexer 12 which is connected to the transmit local oscillator 6 at the frequency TXLO, and the extracted signal of the first receive path E1 is thus downmixed to an intermediate frequency RX2. It is to be noted that, in addition to the actual received signal, the output signal of the receiving amplifier 4 of the first receive path 1 of course also contains the superimposed crosstalk of the first transmit path S1 in the full duplex mode. The output signal of the demultiplexer 12 of the second receive path E2 is fed via a filter circuit 15 to an A/D converter 17 which in turn supplies the data digitized in this way to the baseband block 18. As already mentioned, the second receive path E2 is merely provided as an option and is used in this case to sense the crosstalk of the first transmit path S1 which is frequency-dependent where possible.

The operation of the full duplex (frequency division multiplex) transmitter illustrated in the figure will now be explained. According to the invention, the following steps are carried out in order to eliminate crosstalk portions:

The invention provides the second transmit path S2 which can be driven by the baseband block 18 independently of the first transmit path S1. The output power of this auxiliary transmit path S2, i.e. the

corresponding amplification of the amplifier 5 is significantly smaller in comparison to the output power which is made available by the power amplifier 3 of the actual transmit path S1. The reason for this is that the crosstalk is generally at least 15 dB below the transmit path power if a coupler is used

or if two antennas are used for separating the transmit and receive signals. For this reason, the energy consumption in the second auxiliary transmit path S2, in particular, of the energy consumption by the auxiliary transmit amplifier 5 is very low in comparison to the energy consumption relating to the actual transmit path S1.

As the next step, the crosstalk in the baseband block 18 is sensed. The phase and amplitude of the crosstalk are thus sensed. A prerequisite for this is the channel selection is made in the baseband. This means that the crosstalk is transmitted to the baseband block 18 superimposed on the actual receive signal without pre-filtering. If, as is the case in the figure, the crosstalk superimposed on the actual receive signal is fed to the baseband block 18 filtered (filter 13) in the first receive path E1, the second receive path E2, which has an additional intermediate frequency circuit (demultiplexer 12) is provided. The crosstalk can thus be sensed separately.

As the next step, after the sensing of the crosstalk, to be more precise, after the sensing of both the phase and the amplitude of the crosstalk, an algorithm is executed in the baseband block 18 in order to set the phase and the amplitude of the output signal of the auxiliary transmit path S2 by means of corresponding driving by the baseband block 18, in such a way that the crosstalk is actively compensated (coupler 19). The auxiliary transmit path S2 is therefore driven by the baseband block 18 in such a way that the crosstalk which is continuously sensed drops below a predetermined acceptable limiting level. As soon as the crosstalk which is continuously sensed in the baseband block 18 has dropped below the aforesaid limiting level, the transmitter, i.e. to be more precise, the receive path E1, can be operated without being

adversely affected by crosstalk from the transmit path S1.

In the event of the crosstalk having a strong frequency dependence within the transmit bandwidth of the transmit path S1, this frequency dependence of the crosstalk is sensed in the baseband block 18, evaluated and, if appropriate, the phase and amplitude of the crosstalk are stored in the baseband block 18 as a function of the frequency within the transmit frequency range. In the event of a strong frequency dependence of the crosstalk within the transmit bandwidth, the auxiliary transmit path S2 is driven using the transfer function of the crosstalk multiplied by the inverted transmit signal (in the frequency domain). For a software-defined telecommunications radio device which is operated in the time domain, this means that a convolution calculation is carried out in the baseband block 18 in order to do this.

The present invention can therefore actively eliminate crosstalk from the transmit path, i.e. bring it below a specific limiting level, in particular in software-defined telecommunications radio devices, so that the receive path is no longer adversely affected by the crosstalk. In comparison with the prior art, the invention therefore has the further advantage that sideband noise of the transmit oscillator is suppressed.

List of reference symbols

1	Antenna
2	Duplexer
3	Transmitting power amplifier
4	Receiving amplifier
5	Auxiliary transmitting amplifier
6	Local oscillator (transmit path S1)
7	Multiplexer
8	D/A converter
9	Receiving local oscillator
10	Demultiplexer
11	Multiplexer
12	Demultiplexer
13	Filter
14	D/A converter
15	Filter
16	A/D converter
17	A/D converter
18	Baseband block
19	Coupler
S1:	First transmit path
S2:	Auxiliary transmit path
E1:	First receive path
E2:	Second receive path

Patent claims

1. A frequency division multiplex transmitter, having a baseband block (18), a first transmit path (S1) and a receive path (E1) which respectively transmit and receive simultaneously on different frequencies, an auxiliary transmit path (S2) is provided which is connected to the receive path (E1) and which adds to the received signal (E1) a signal whose phase is shifted by 180° with respect to the phase of the transmit signal and which has the same frequency or the same frequency range as the transmit signal, characterized in that the auxiliary transmit path (S2) can be driven by the baseband block (18) independently of the first transmit path (S1).

2. The frequency division multiplex transmitter as claimed in claim 1, characterized in that the baseband block (18) senses crosstalk of the first transmit path (S1) and drives the auxiliary transmit path (S2) as a function of the sensing of the crosstalk.

3. The frequency division multiplex transmitter as claimed in claim 2, characterized in that the baseband block (18) senses the amplitude and phase of the crosstalk of the first transmit path (S1) as a function of the transmit frequency.

4. The frequency division multiplex transmitter as claimed in claim 2 or 3, characterized in that, in order to sense the crosstalk of the first transmit path (S1), the receive signal and the crosstalk can be fed unfiltered to the baseband block (18).

5. The frequency division multiplex transmitter as claimed in claim 2 or 3, characterized in that, in order to sense the crosstalk of the first transmit path (S1), a second receive path (E2) is provided which has an intermediate frequency converter (12) which downmixes the crosstalk on the basis of the transmit frequency just used.

6. The frequency division multiplex transmitter as claimed in one of the preceding claims, characterized in that the baseband block (18) drives the auxiliary transmit path (S2) to minimize the sensed crosstalk of the first transmit path (S1).

7. The frequency division multiplex transmitter as claimed in one of the preceding claims, characterized in that the baseband block (18) drives the auxiliary transmit path (S2) in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

8. The frequency division multiplex transmitter as claimed in one of the preceding claims, characterized in that, in order to drive the auxiliary transmit path (S2), the baseband block (18) carries out a convolution calculation of the crosstalk with the transmit signal in the time domain.

9. A method for eliminating crosstalk in a frequency division multiplex transmitter which has a baseband block (18) and a first transmit path (S1 and a receive path (E1) which respectively transmit and receive simultaneously on different frequencies, an auxiliary transmit path (S2) being provided which is connected to the receive path (E1)

and which adds to the received signal (E1) a signal whose phase is shifted by 180° with respect to the phase of the transmit signal and which has the same frequency or the same frequency range as the transmit signal, characterized in that the baseband block (18) drives the auxiliary transmit path (S2) to minimize the crosstalk, independently of the first transmit path (S1).

10. The method as claimed in claim 9, characterized in that the baseband block (18) senses crosstalk of the first transmit path (S1) and drives the auxiliary transmit path (S2) as a function of the sensing of the crosstalk.

11. The method as claimed in claim 10, characterized in that the baseband block (18) senses the amplitude and phase of the crosstalk of the first transmit path (S1) as a function of the transmit frequency.

12. The method as claimed in claim 10 or 11, characterized in that, in order to sense the crosstalk of the first transmit path (S1), the receive signal and the crosstalk are fed unfiltered to the baseband block (18).

13. The method as claimed in claim 10 or 11, characterized in that, in order to sense the crosstalk of the first transmit path (S1), a second receive path (S2) is used in which the crosstalk is downmixed (12) on the basis of the transmit frequency just used.

14. The method as claimed in one of claims 9 to 13, characterized in that the baseband block (18) drives the auxiliary transmit path (S2) in the frequency domain using a transfer function of the crosstalk multiplied by the inverted transmit signal.

15. The method as claimed in one of claims 9 to 14, characterized in that, in order to drive the auxiliary transmit path (S2), the baseband block (18) carries out a convolution calculation of the crosstalk with the transmit signal in the time domain.

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

<u>FREQUENZMULTIPLEX-TRANSMITTER UND VERFAHREN ZUR AUSLOESCHUNG VON UEBERSPRECHEN</u>

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 03.03.1999 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE99/00562
eingereicht wurde und am ______
abgeändert wurde (falls tatsächlich abgeändert).

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

<u>FREQUENCY MULTIPLEX TRANSMITTER AND METHOD FOR ELIMINATING CROSSTALK</u>

the specification of which

(check one)
☐ is attached hereto.
☒ was filed on 03.03.1999 as
PCT international application
PCT Application No. PCT/DE99/00562
and was amended on __________
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

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IDNR: 2590 / V: 99-1.00 / B:Val

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	☐ Yes Ja	☐ No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

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PCT/DE99/00562	03.03.1999	anhängig	pending
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D, M, Y) (Anmeldedatum T, M, J)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: *(Name und Registrationsnummer anführen)*

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)* .

And I hereby appoint

Customer No. 21171

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Staatsangehörigkeit: DE	Citizenship: DE
Postanschrift: Isardamm 121 b	Post Office Addess: Isardamm 121 b
82538 Geretsried	82538 Geretsried
Voller Name des zweiten Miterfinders (falls zutreffend): Dr. XIHE TUO	Full name of second joint inventor, if any: Dr. XIHE TUO
Unterschrift des Erfinders / Datum	Second Inventor's signature / Date
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Lake Forest, CA 92630	Lake Forest, CA 92630

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

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Erklärung Für Patentanmeldungen Mit Vollmacht
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Prioritát beansprucht

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PCT/DE99/00562 (Application Serial No.) (Anmeldeseriennummer)	03.03.1999 (Filing Date D, M, Y) (Anmeldedatum T, M, J)	anhängig (Status) (patentiert, anhängig, aufgegeben)	pending (Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

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Voller Name des einzigen oder ursprünglichen Erfinders: THOMAS OSTERTAG	Full name of sole or first inventor: THOMAS OSTERTAG
Unterschrift des Erfinders Datum	Inventor's signature Date
Wohnsitz Geretsried, DEUTSCHLAND	Residence Geretsried, GERMANY
Staatsangehörigkeit DE	Citizenship DE
Postanschrift Isardamm 121 b	Post Office Addess Isardamm 121 b
82538 Geretsried	82538 Geretsried
Voller Name des zweiten Miterfinders (falls zutreffend): Dr. XIHE TUO	Full name of second joint inventor, if any: Dr. XIHE TUO
Unterschrift des Erfinders Datum 1-14-02	Second Inventor's signature Date
Wohnsitz Lake Forest, CA 92630, VEREINIGTE STAATEN VON AMERIKA CA	Residence Lake Forest, CA 92630, UNITED STATES OF AMERICA
Staatsangehörigkeit XT DE	Citizenship DE
Postanschrift 23333 Ridge Route Apt. # 53	Post Office Address 23333 Ridge Route Apt. # 53
Lake Forest, CA 92630	Lake Forest, CA 92630

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